Partnership to Improve the Middle School Science and Mathematics

Abstract

The purpose of this proposal is to create an opportunity for middle school science and mathematics teachers who teach in the urban and suburban schools in the Denver Metro area or in the rural schools on the Western Slope to comply with the requirements of No Child Left Behind (NCLB). As a result of prior collaborations, a partnership has been developed among the following ten school districts: Adams County District 50, Delta, Denver, Haxtun, Montezuma-Cortez, Montrose, Park County RE-2, Plateau Valley, Sheridan, and St. Vrain Valley, and two institutions of higher education, Colorado School of Mines (CSM) and Regis University (RU). As part of this proposal, instructional units addressing middle school science and mathematics that have been created as part of prior grants will be redesigned as hybrid courses consisting of one week of online instruction and one week of classroom based instruction. Two hybrid summer courses will be offered to our partner school districts in the summer of 2008. In the Western Slope, a class based on the television show, NUMB3RS, will be presented. ALICE, an object-oriented educational programming language, will be presented in the Denver Metro area.

Theoretical Background

In 2001, the "No Child Left Behind Act" (NCLB) (Council for Exceptional Children, 2001) was signed into law in the United States. NCLB is designed to hold pre-college schools accountable for the academic achievements of their students, and has been cited as the most challenging educational reform act since the Elementary and Secondary Education Act of 1964 (Berkeley County School District, 2004). The goal of NCLB is to close achievement gaps among students from different ethnic groups, genders and economic backgrounds (Public Schools of North Carolina, 2004). In addition, NCLB requires states to develop and implement annual assessments in mathematics and reading in grades 3-8 and at least once in grades 10-12. Beginning in 2007-2008, schools must administer annual tests in science achievement, at least once in grades 3-5, 6-9, and 10-12 (U.S. Department of Education, 2002).

As part of NCLB with the purpose of ensuring teacher quality, "teaching out of field" is no longer acceptable. States must ensure that all teachers who provide instruction in the core academic subjects of reading, mathematics, and science are "highly qualified" within their respective content area. To be "highly qualified", teachers must match the following criteria: 1) have full state certification, twenty-four credit hours, or pass the teacher licensing exam within the content area that they teach; 2) have a license to teach within the given state; and 3) not have had the license or certification waived. In addition, the law requires all new and existing elementary and middle school teachers to have at least a bachelor's degree. These requirements have left many practicing teachers struggling to maintain their credentials (U.S. Department of Education, 2002).

The purpose of this proposal is to create an opportunity for middle school science and mathematics teachers who teach in urban and suburban schools in the Denver Metro area or in rural schools on the Western Slope to comply with the requirements of NCLB. The Colorado School of Mines (CSM) and Regis University (RU) have already established, through prior grants, partnerships

with the following school districts in the Denver Metro area: Adams 50, Denver, Haxtun, Park County RE-2, Sheridan, St. Vrain, and the following districts on the Western Slope: Delta, Montrose, Montezuma-Cortez, and Plateau Valley. A primary goal of this proposal is to increase the impact of these prior efforts by including more of the partner districts' middle school science and mathematic teachers. This will be accomplished through the development of a hybrid summer course that will consist of one week of online instruction and one week of classroom based learning. This design was developed for the following reasons. 1) Approximately half of the instructional material designed for these courses can be successfully delivered online. 2) Many teachers have summer obligations that prevent them from completing extended summer courses. Examples include assuming summer child care responsibilities and acquiring summer employment. By minimizing the classroom based requirements, teachers in these situations are more likely to be able to participate. Expert teachers within our partner schools have assured us that most teachers within their district can attend a summer workshop, if course attendance is limited to a single week.

Through previous grants, CSM has developed instructional units that are designed to improve middle school teachers' knowledge of science, technology, engineering and mathematics. As part of the current proposal, two of these two-week summer workshops will be converted to hybrid courses, which included one week of on-line instruction and one week of classroom based instruction. The methodology proposed here was pilot tested through the support of CCHE on one course in the summer of 2007 and this course was successfully delivered to 25 middle school science and mathematics teachers on the Western Slope. We propose here the extension of these efforts by converting and delivering two additional courses in the hybrid format. RU's role in this partnership is in the evaluation of the instructional materials and outcomes of the hybrid courses. Science and mathematics were jointly selected as the focus for this proposal, since it is common practice to assign teachers certified in science to also teach mathematics and vice versa.

This proposal directly responds to the following focus areas in the request for proposals:

- *Local or school-based courses that allow current teachers in rural areas to enroll in and complete content coursework and become **"highly qualified"** instructors and offered to such teachers at no cost;* and
- *New courses, or existing sections made available at convenient times and locations, offered to teachers at no cost, that allow current teachers to enroll in and complete content coursework in order to become **"highly qualified**": instructors in math and science.*

Prior Work

Over the last six years, Drs. Skokan and Moskal, have been investigators, curriculum developers and instructors for seventeen summer courses for middle school science and mathematics teachers. Middle school is defined here to refer to grades six through eight. These courses have been supported by the National Science Foundation (NSF), the Colorado Department of Education (CDE) and the Colorado Commission (now Department) of Higher Education (CC/DHE). To date, over 200 teachers from seventeen different school districts have completed these courses. The impact of these projects within the year of intervention is estimated to be over 20,000 students.

Each of these courses has the same primary purpose: to improve in-service teachers' knowledge and understanding of science and mathematics, thereby, improve the instruction that middle school students receive in these subjects. Each of these courses is further based on the same philosophical assumption: science and mathematics are related subjects that should be taught through hands-on experiences. This assumption is supported by the American Association for the Advancement of Science (1993), National Science Board (1999) and the National Council of Teachers of Mathematics (1989; 1991; 1995; 2000; 2002) and the University of Illinois at Chicago (2007).

In these courses, the natural connection between mathematics and science is illustrated to the participating teachers through engineering activities and the use of technology. Each activity is specifically designed to be linked to the Colorado State Departments' K12 Academic Standards for Mathematics and Science (Colorado Department of Education, 2007). The proposed project builds off of these efforts and, in particular, off of the Colorado Department of Education funded grant, "Physical Science in the Middle School Classroom" and an NSF grant "An Innovative Approach for Attracting Students to Computing". As a result of the project, "Physical Science in the Middle School Classroom", four two-week summer courses were developed and implemented in the urban and suburban school districts surrounding the Denver Metro area:

1. CDE I: Physical Science and Mathematics – Engineering Connections (36 teachers)
2. CDE II: Advanced Physical Science and Mathematics (26 teachers) and
3. CDE III: Technology for Teachers (25 teachers)
4. CDE IV: NUMB3RS for Mathematics and Science Teachers (27 teachers)

The NSF grant has funded a workshop on ALICE for high school teachers during the summer of 2007. ALICE is a free, open source, object-oriented educational programming language with an associated development environment. ALICE uses a drag-and-drop environment to crate computer animations.

The CDE sequence of courses is designed to begin at an elementary mathematics level (fractions and decimals) and, across the four year sequence, build to the inclusion of trigonometry and basic statistics. With respect to science, the curriculum covers physics and chemistry. Topics include motion and energy, heat, light, sound, electricity, compounds and mixtures, acids/bases, heat of reactions, polymers, and electrochemistry. Middle school mathematics and science teachers that complete the full four year sequence have a thorough review of middle school and high school mathematics and science. They also have a selection of standards based activities that illustrate the applications of science and mathematics to engineering that they may use in their classroom.

Through a combination of funding from CC(D)HE and the Colorado Department of Education, the above courses have been offered to a mix of teachers in the Denver Metro area and on the Western Slope. Based on our assessment results (Moskal et al., 2007), these efforts have been highly effective for improving teachers content and pedagogical knowledge. Many teachers, however, select not to complete these courses because of the two-week in-class summer requirement. These teachers often have summer child

care responsibilities or summer employment. By reducing the in-class requirement to one week, expert teachers within the districts have assured us that the majority of teachers will be able to participate. This is based on the following: 1) one week of child care as opposed to two weeks significantly decreases the financial burden, and 2) many summer jobs provide for a one week vacation. The two courses that were selected to be converted to the hybrid version are NUMB3RS for Mathematics and Science Teachers and ALICE in the Middle School Classroom. These were selected because of the recommendations of middle school teachers who have participated in former workshops in these topics and the ease of dividing the courses into on-line and classroom portions. The NUMB3RS course was offered in the Denver Metro area in the summer of 2007 and would be rearranged in hybrid form for the Western Slope for the summer of 2008. ALICE will be offered to high school teachers in the summer of 2008 in the Denver Metro area. This proposal addresses offering a middle school version in the Denver Metro area. The online component will provide a great deal of flexibility in terms of when the teachers can complete the first week of material. The second week will be classroom based and will consist of activities that illustrate how the on-line instruction can be delivered to students through hands-on activities.

Objectives

The objectives of this proposal, labeled with the prefix "O", are as follows:

O1. Improve middle school science and mathematics teachers' knowledge of the disciplines that they teach.

O2. Assist middle school science and mathematics teachers in developing a repertoire of standards based teaching strategies, activities and lesson plans that employ current technology for their classroom.

O3. Provide middle school mathematics and science teachers the opportunity to acquire the designation of "highly qualified" through college course work.

O4. Examine the effectiveness of combining online learning with classroom based instruction for the improvement of the content and pedagogical knowledge of middle school mathematics and science teachers.

O5. Examine the effectiveness of the proposed program for teachers for improving the CSAP scores of students in participating teachers' classroom.

Partnership and Collaboration

This partnership includes the school districts: Adams County District 50, Delta, Denver, Haxtun, Montezuma-Cortez, Montrose, Park County RE-2, Plateau Valley, Sheridan and St. Vrain Valley, and the institutions of higher education of CSM and RU. Two programs at CSM will participate, Mathematical and Computer Sciences (MCS) and the Engineering Division (Eng) and one program, the Education Department (ED), will participate from RU.

School Districts. Table 1 summarizes the demographic and recent Colorado Student Assessment Program (CSAP) information currently available for each of the participating school districts. As this table suggests, all of the participating districts have a large percentage of student receiving free or reduce cost lunches and for some of the districts, more than 30%of the teachers are providing instruction outside the field in which they are certified. Furthermore, within some of the participating districts, over 20% of the students performed at the "unsatisfactory" level on the most recent 8th grade CSAP for both science and mathematics. In the 2004 census (highlighted in green), **Denver Public Schools** and **Park County RE-2 District** were identified as areas where at least 20% of the children are below the poverty line. Furthermore, **St. Vrain Valley, Denver County, Sheridan, Montezuma-Cortez**, and

Montrose (highlighted in yellow) did not make AYP in 04-05, did not make HQ classroom targets, and have a lower percentage of HQ classes than the state. The blue highlights indicate that the district failed to meet their HQ target. In summary, all of the participating districts are high need and require immediate assistance in order to comply with the requirements of NCLB.

Table 1. Student and Teacher data for participating districts 2005-6 (www.cde.state.co.us)

	Montrose	Delta	Montezuma-Cortez	Plateau Valley	Park County (RE-2)	St Vrain Valley	Adams 50	Haxtun	Sheridan	Denver
Total Students in District	3168	2809	1531	167	324	12009	5567	158	725	34884
Native American	1%	1%	29%	2%	2%	1%	1%	0%	1%	1%
Hispanic	29%	18%	14%	11%	8%	26%	64%	4%	66%	58%
Caucasian	68%	92%	56%	86%	90%	68%	26%	92%	26%	19%
Black	1%	1%	1%	1%	0%	1%	2%	2%	3%	21%
Free or Reduced Lunch	51%	41%	57%	34%	38%	28%	68%	41%	83%	67%
8th Grade CSAP-Math, unsatisfactory	26%	17%	28%	14%	6%	17%	39%	4%	38%	46%
8th Grade CSAP-Science, unsatisfactory	21%	13%	25%	10%	0	16%	34%	4%	37%	44%
Teachers teaching out of field	26%	3%	40%	64%	36%	17%	20%	6%	28%	41%
Total Teachers in District	379	285	218	35	55	1355	678	25	111	4044
% poverty					20%					21%
% HQC	91.71%	95.32%	90.87%	98.81%	89.48%	82.07%	97.92%	94.15%	92.21%	83.92%

CSM. CSM is the second oldest and one of the largest colleges of mineral engineering and applied science in the U.S. Through its Office of Special Programs and Continuing Education (SPACE), CSM offers more science content-based teacher (K-12) recertification courses than any other institution in Colorado. As a direct result of SPACE''s activities, CSM has been nationally recognized as a leader in both teacher training and K-12 curriculum design. The participating faculty, Drs. Skokan and Moskal, are members of the academic departments of Eng and MCS, respectively, and both have extensive experience working with the SPACE office on K-12 outreach activities.

RU/ED. RU/ED program provides an appropriate, performance based education to students who are interested in pursuing a Colorado Teacher Licensure in elementary (K-6) or secondary education (7-12). This program fosters individualized field placements, collaborative mentoring, and personal advising, and is widely respected within the education community of Colorado. Graduates are highly sought by public and private schools throughout the region. Three members of the RU faculty will participate in the proposed program, Drs. Michael Ghedotti, Suzaane Caulk and Heidi Barker. Drs. Ghodotti and Caulk expertise lies in the preparation of future science and mathematics teachers, respectively. Dr. Barker specializes in educational assessment. This team will provide an external evaluation of our pedagogical approach and appropriateness of course materials for standards-based middle school curriculum.

Work Plan

The proposed plan includes several components. First, instructional units that have been created as part prior grants will be converted for one-week online and one week in class delivery. Second, these courses will be offered to participating teachers in the summer of 2008. Finally, an academic year follow-up is designed to encourage teachers to use what they have learned in their classrooms.

On-line Development and Deliver. A graduate student will be supported throughout the proposed project. Under the direction of Drs. Skokan and Moskal, this student will convert a selection of the current instructional units to online units during the spring of 2008 using the Blackboard educational software. Blackboard is a program designed to support the development and delivery of on-line courses. Drs. Skokan, Moskal, Ghedotti and Caulk will review and provide feedback on these units with respect to both content and pedagogy. Each online unit will include embedded assessment activities which the participating teachers will be required to complete. Dr. Barker, an assessment specialist, will assist in the development of the online assessments. The online materials will be available to participating teachers throughout the late spring and summer of 2008.

Classroom Based Summer Course. As part of this proposal, the participating teachers will also complete the one-week classroom based summer course. One such course will be offered in the Denver Metro area and the other on the Western Slope. This course will be seven hours per day for five days. During the course, the teachers will complete the hands-on instructional units that could not be successfully converted to the online environment. For example, math and science teachers teams will work to determine location from a shadow . Both the morning and afternoon session of the classroom component of this course will focus on hands-on activities designed to improve the participating teachers' knowledge and understanding of how science, mathematics, engineering and technology can be used to enhance science and mathematics instruction. The one week summer course in combination with the online instructional materials is designed to support the attainment of O1, O2 and O4. Appendix A details the on-line topics and the classroom schedules.

Academic Year Follow-up. To provide a sustained experience into the academic year and to further support the participating teachers, the Blackboard site will be maintained throughout the fall semester by the participating graduate student. Teachers will further be encouraged to post their questions concerning content or pedagogy on a course discussion board. Although the participating faculty members will also monitor this site, the graduate student will be responsible for completing the appropriate research to respond to the posted questions. The graduate student will also be available for classroom visits to support the teachers in hands-on activities and to be a role model for the middle school students. The follow-up activities are primarily designed to support O1 and O2

Continuing Education Credit. The combination of the online and in-class activities in the completion of the summer course will result in the awarding of four continuing education credits. In order to receive these credits, participating teachers will be required to complete and pass all online and classroom assessment activities. This component of the projects is designed to support the attainment of O3.

Partnership Coordination

Given the remote location of some of the participating schools, local consultants are necessary for project implementation. Two expert teachers, Mr. David Saksek (Montrose County) and Mr. Kevin Sheppard (Delta County), will oversee the teacher recruitment and on-line instruction on the Western Slope. These instructors will travel to CSM early in the summer of 2007 to receive training from Drs. Skokan, Moskal, Ghedotti and Caulk on course delivery. Phone and e-mail contact will further be maintained throughout this project among course developers and the expert teachers. Drs. Skokan and Moskal as well as the participating graduate student will provide on-site instruction for the one-week classroom based component of the courses. One course will be offered in the Denver Metro area and the other on the Western Slope. A timeline for the grant activities is located in Appendix B. Biographical information with respect to participants for this project is contained in Appendix C.

Teacher Recruitment

Recruitment efforts will focus on middle school mathematics and science teachers in the identified school districts. Flyers announcing the course will be directly mailed to prior course participants and principals in the participating districts will distribute recruitment flyers to appropriate teachers. Participation in this program will further be encouraged through the awarding of continuing education credits, the offering of stipends and funds to support the purchase of classroom supplies. For teachers traveling more than 50 miles to attend a course, housing will be provided for the one week on-site portion of that course.

Evaluation

Dr. Heidi Barker, RU, will act as the evaluator of this project. In the development of this assessment plan, careful consideration has been given to both formative and summative evaluations. Data collected through formative evaluation will provide information that will be utilized in refining objectives, content, and methods for the delivery of the proposed program. The summative portion will examine the extent to which the project objectives have been reached. A major component of the summative evaluation will be the statistical comparisons of student performances between the treatment and control classrooms. Control scores will be based on the participating teacher's students' average CSAP score prior to the intervention; treatment scores will be based on the participating teacher's students' average CSAP score after the intervention. This component of the project is designed to support the obtainment of O5.

Formative Evaluation. At the conclusion of each day of the classroom portion of the summer course, the participating teachers will respond anonymously to the following questions: 1) What have you learned in today's class?, 2) What questions do you

have concerning the content presented? and 3) Is there any information that was discussed that you would like to know more about? The teachers' responses to these questions will be used to prepare the next class.

Teachers will also be encouraged through the online discussion board to post questions while completing the online materials as well as once they begin to implement these materials in the classroom. A graduate student will be responsible for reviewing, researching and responding to these questions. The evaluator will review both the time stamps for the graduate student's response as well as the nature of the graduate student's response. This will ensure that responses are both prompt and accurate.

Summative Evaluations. A participant questionnaire will be developed to acquire teachers' feedback at the end of the course as to the extent to which they have reached O1-04. A survey will be sent at the end of the fall semester to determine the extent to which participating teachers have advanced towards the attainment of the "highly qualified" designation (O3). Participating teachers will also complete a pre and post assessment at the start and finish of each of the courses (O1) and their improvement will be compared to that which was attained in prior implementations of the courses (O4). Finally, a statistical comparison will be made between the baseline CSAP scores and the participating teachers' students' yearly progress with respect to these scores (O5).

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